REVIEW ARTICLE

Application of Herbs for Wound Dressings - Review

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ABSTRACT: A dressing is a sterile pad or compress applied to a wound to promote healing and protect the wound from further damage. Wounds are defined as self healing process but chronic wounds needs better handling and care from different parameters like moist conditions, application of herbs biocompatibility, and microbial infections. Wound dressing gives excellent wound healing than conventional/ traditional wound dressing. Some of the examples are Hydrogels, hydrocolloid, mapilex foam, etc. Traditional wound dressing is used to treat minor injuries like cuts. Eg: Normal saline and guaze. Several studies have documented the use of plant extracts for development of bioactive wound dressing. This review focuses on bioactive substances, natural and modified polysaccharides, proteins and synthetic materials in wound dressing for wound healing. Ideal wound dressing should achieve the wound healing with less time and cost. Significance of synthetic polymer films, foam dressing, hydrocolloids, hydrogels, and alginate dressing and their properties conforming the wound healing have been reviewed. Plant derived compounds which have anti-inflammatory, anti-microbial, high levels of antioxidants could be benefited for wound healing. Vegetal and bee products such as honey, Propolis and many more used in wound dressing as a bioactive substance is also discussed.

KEYWORDS: wound dressing, wound healing, alginate, chitin, chitosan, Carboxymethyl cellulose (CMC), hydrogel, hydrofibre, honey, and marigold.

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INTRODUCTION

Health care is an essential aspect of human survival. Wound healing is a complex and dynamic process. Wound dressing contains two layers: First layer is located adjacent to the wound and comprises a material which should be bioadsorbable, porous and also compatible for serving as a scaffold for cell attachment and proliferation. Second layer is in contact with first layer and comprises an absorbent, gel forming material adapted for serving as a barrier to cell adhesion and penetration [1,2]. There are two kinds of dressing:

1) dry/ traditional wound dressing.

2)wet/ moist or ideal wound dressing.

Traditional wound dressing function is to absorb exudates, cushion the wound, allow for a dry site, hide wound from view and provide barrier to contamination.

In ancient times, linen textile structures were coated with honey, gums, resins and herbal extracts to make them anti-microbial. In another major study in ancient Greece, some metal powder, milk, honey, and wine were used in guaze application. It was observed that when metallic copper is combined with vinegar, copper acetate is obtained, which had anti-bacterial properties. It was used in the treatment of wounds and cutaneous ulcers [3]. Medicinal plants have been used for several years as traditional treatment for various diseases. Source of biological active compounds are naturally derived products from medicinal plants, which start the development of new chemicals for pharmaceutical industries. Properties of vegetal extracts have effects such as anti-infectious, anti-oxidant, anti-cancer and so on. For infectious diseases antibiotics and anti-viral agents are used and have led to the regaining interest for discovery of natural compounds.

Basic function of wound management is to promote rapid wound healing. Large variety of textile fibres such as cotton, silk, and wool also structures such as knitted, non woven, and composites were traditional wound dressing materials. Cotton guaze impregnated with paraffin as a wound dressing was developed later. The use of anti-biotics in wound and wound healing was introduced. Various such developments were studied by the scientists [4]. When wound is left open to air, scab (dry covering) covers the wound which decreases the rate of epithelialisation. Cotton guaze dressing were used earlier and now not common because of some disadvantages: inability to prevent microbial invasion, can only be used for minor wounds and not for chronic wounds [5,6,7].

Advanced wound dressing are used for chronic wounds such as severe ulcers, amputations and deep lacerations. This may keep temperature consistent, allow flow of oxygen, protect site from exogenous infections, remove dead tissues, and ease pain associated with dressing changes. This keeps the wound in moist conditions [11]. Moist environment is

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preferable for wound healing as it prevents additional tissue loss from dessication. There are four phases during the healing of wounds such as: Homeostasis, inflammation, granulation tissue formation, remodelling [12,13]. Advanced wound dressing reduces infection risks, pain and discomfort, and life. During healing in wet environment renewed skin is obtained without formation of eschar (a dry, dark scab typically caused by burn). Ideal wound dressing should have properties such as biocompatible and elastic, non-allergenic, easy and comfortable to remove, etc. It has been reported that wet wound healing is faster than the dry wound healing. This includes film and foam dressing, alginates and hydrocolloids, hydrogels, polysaccharide pastes, and many more [8].

Textile based composite structures are good materials for wound dressing because of their properties such as large porosity, surface area, air and moisture permeability. Textile materials provide strength, flexibility and extensibility. Fibres, generally used in wound care are grouped into natural and manmade categories. Most important natural fibres are cotton, silk and linen. Man made synthetic polymers cover fibres manufactured from chemically synthesized polymers like polyester, polyamide, polypropylene, polyurethane, etc. Fibres manufactured from naturally available polymers like alginates, proteins, polyglocotic acid, regenerated cellulose, chitin, chitosan, etc. Some non-fibrous materials such as carbon and metals (silver) are used [15,16]. Polymeric materials with specific characteristics have generated interest in biomedical applications.[9]

Phytochemicals are non nutritive substances present in plants enhances tissue remodelling when applied on wounds and acts as pro-angiogenic agents for wound healing. Plants extract used in wound management are essential oils, Marigold, Aloevera, curcumin, propolis, Honey, Tree barks and so forth. [17].

Phytochemicals and Plant extracts used in wound dressing:

Aloe Vera: It has been used to treat various ailments of the skin. Various studies reported that Aloe vera has useful effects on wounds especially on cutaneous wound healing. It has been shown to increase collagen production in the skin which helps with wrinkle reduction and more youthful looking radiant skin. The whole gel extract of aloevera has been reported to promote wounds, burn, frost-bite healing, pressure ulcers, etc as they have properties such as anti-microbial, anti-inflammatory, anti-bacterial, anti-viral, strong immune modulatory. Aloe vera gel consists of water and polysaccharides including pectins, cellulose, hemicellulose, glucomannon and acemannan, the latter being the main component of aloevera gel formed from long chain of acetylated mannose [18]. Mannose-6-phosphate increases wound contraction and collagen synthesis [19]. Aloe vera based cream was found to be saline-moistened guaze in healing of pressure induced ulcerations. ß-sitosterol (found in aloe vera mucilage) increases angiogenesis and promotes better healing of traumatic tissues. Another bioactive dressing was designed using collagen- chitosan scaffolds supplemented with Aloevera[20,21].

Curcumin: It is a natural yellow phenolic antioxidant compound present in many kinds of herbs particularly in turmeric. It contains methoxy groups and phenols which has anti-inflammatory, anti-oxidant, anti-carcinogenic, anti-mutagenic, anti-coagulant, anti-infective properties. Curcumin is used to treat many diseases such as cough, diabetes, anorexia, cancer, hepatic disorders, alzheimer disease, etc. Curcumin has hepato protective, nephro protective, cardio protective, neuro protective, hypoglycemic, antirheumatic, and antidiabetic activities and it also suppresses thrombosis and protects against myocardial infarction.[17,22]. Curcumin has been used in different nano formulations used to increased solubilisation of curcumin but at the same time protect curcumin against inactivation by hydrolysis: liposomes, polymeric nanoparticles, polymeric micelles, conjugates, peptide/protein carriers, cyclodextrins, solid dispersions, etc.[23]. Curcumin is involved in tissue remodeling, granulation tissue formation, and collagen deposition and increases fibroblast proliferation and vascular density .

Essential oils: It is used in skin care and treatment. Various types of oil extracts have anti-bacterial, anti-microbial, anti-inflammatory, emollient, moisturising, etc properties [1]. An extracted oil from pumpkin seeds (Cucurbita pepo L.) can be a promising drug for healing wounds in animal studies (uniform wounds induced on the dorsum of rats) due to a high content of polyunsaturated fatty acids (linoleic acid, 50.88 ± 0.106 g/100 g of total fatty acids), tocopherols (280 ppm), and sterols (2086.5 ± 19.092 ppm) [24]. A poly-herbal cream containing aqueous extracts of Malvasylvestris and Solanumnigrum leaves and oily extracts of Rosa damascena petals, retrieved from Iranian traditional medicine, showed desirable reepithelialization with remarkable neovascularization with less inflammatory cells.[25].

Marigold: Calendula offcinal is (marigold) is a plant species part of daisy family. The Calendula officinalis extract contains different classes of compounds, such as triterpenoids, flavonoids, coumarins, quinones, volatile oil, carotenoids, and amino acids , but the active compound consists mainly of carotenoids (carotene, lycopene, flavoxanthin, lutein, and rubixanthin) and faradiol.It is used in clinical applications such as wounds, leg ulcers, first degree burns, skin rashes (acute dermetatis for breast cancer treatment). This is used for its anti-inflammatory, anti-fungal, anti-viral and wound healing activities. [26].

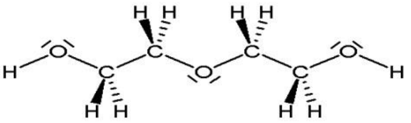
Banana leaf: Banana leaves have been studied as low cost dressings for partial thickness burn wounds and donor sites. Unrandomized, controlled studies showed that sterilized banana leaf dressings showed a greater rate of re-epithelialization in comparison to Vaseline gauze in donor site healing. Sterlized banana leaves must be used within 3-4 days as fungal overgrowth can occur after one week. Various reports have been studied and there were no reports of allergic or irritant reactions.[27].

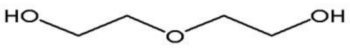
Tree barks: Bark extracts are rich source of plant polyphenols and tannins that have anti-microbial, anti-oxidant, anti-inflammatory and astringent properties. Various extracts are used in wound healing. Aqueous bark extracts of red mangrove have been used to improve healing of various extracts are used in wound healing. Aqueous bark extracts of red mangrove have been used to improve healing of acute surgical wounds and aphtous ulcers with no infections. A proprietary ointment (Bensal HP) that contained extracts from oak bark was superior to sulphadizine in healing of diabetic ulcers in experiments [28,29].

Naturally derived substances used in wound dressing:

Propolis: It is a complex resinous mixture collected by bees from exudates of plants with high medicinal value. It has anti-oxidant, anti-microbial and anti-inflammatory properties. Propolis rarely causes contact dermatitis or severe allergic responses. This is a valuable bee product [30, 31].

Honey: Honey is mostly a concentrated aqueous solution composed of a mixture of fructose and glucose, but it also contains some amounts of near 30 other complex sugars. It is commonly used for wound healing as it has many advantages such as anti-inflammatory, anti-oxidant, anti-microbial and osmotic properties [32]. Manuka honey was the first naturally derived substance that has been approved for wound care by (FDA) Food and Drug administration. A systematic review of all the available well-done randomized, controlled clinical studies revealed that honey was beneficial in the treatment of acute burn wounds in comparison to conventional dressings such as Vaseline gauze, but offered no benefit in healing time when compared with silver sulfadiazine. Honey is beneficial for pressure induced wounds, infected post surgical wounds and gangreine [33].





Advanced wound dressing:

Hydrocolloid wound dressing: It is usually a multilayered structure, which consists of an outer layer to provide protection and a supporting material, which may be present in the form of film, foam or fibre. Onto this supporting material is laminated a composite consisting of an adhesive through which hydrophilic particles are distributed [2]. This is a type of dressing which contains gel forming agents such as sodium carboxymethyl cellulose, gelatines, pectin and alginate. Hydrocolloid wound dressing does not allow water, oxygen or bacteria to enter into the wound. This facilitates angiogenesis and granulation. These dressings physically interact with the wound exudates and forms hydrated gel over wound surface. This gel gets separated during dressing removal and avoids damage to newly formed skin [5,9]. Hydrocolloids have acidic pHand this environment inhibits bacterial growth. It is very comfortable to patient's body and adheres well to high friction areas such as sacrum and heels [34]. Some brand name hydrocolloid dressings include comfeel ulcer care dressing (from Coloplast), DuoDerm CGF control gel formula dressing (from ConvaTec), and tegasorb (from 3M Health Care).

Foams and semi permeable films: Foams are porous materials which have flexibility and high absorption capacity. Semi-permeable filmsare sterile sheets of polyurethane coated with acrylic adhesive. As the Films are transperant, wound can easily be observed. They allow autolytic debridement of nectrotic wounds and creates moist healing environment for granulating wounds [5].

Hydrogel wound dressing: Hydrogel is a two component system- First is the hydrophilic polymer and second is water. This system swells in water and regain their original shape. Therefore they provide moist environment for idea dressing. [35]. Hydrogels are commonly used for scaffolds in tissue engineering, biosensors, disposable diapers, contact lenses. This dressing reduces the loss of body liquid and maintains high humidity in wound area. CMC, agar, glycerol and pectin can be used for hydrogel wound dressing production [2,5].

Alginate wound dressing: Alginate fibres have properties such as high absorbency, biodegradability, gelling, and biocompatibility, non-toxic, non-irritant and such like that. Alginates are block copolymers of two hexuronic acid residues, ß-D-mannuronic acid and Alpha-L- guluronic acid with 1-4 glycosidic linkages. Association between calcium ions and two guluronic acid residues forms the gel. Calcium alginate fibres when comes in contact with fluid get partially converted to water soluble sodium alginate that swells to form calcium- sodium alginate gel across the wound. This helps in keeping the wound moist.[9]. Recently one method was reported to incorporate silver based antibacterial to the fibre. Silver sulphadizine (SSD) containing alginate fibres and silver-alginate fibres were produced using various incorporation techniques. SSD was introduced during preparation of spinning solution.[36].

Hydrofibre wound dressing: It contains sodium carboxymethyl cellulose. CMC wound dressing have ability to absorb large amount of body fluids and remove large number of exudates. This decreases the amount of micro organisms on wound surface. CMC dressing is used to heal leg ulcers, pressure ulcers, abrasion, and burns [37].

Polylactic acid: PLA fibre is one of the fastest biodegradable fibres. It has excellent properties such as biocompatibility, low toxicity to humans, etc. It is used in sutures, scaffolds, drug delivery systems. It has higher natural hydrophilicity than other polymers such as PET, Polypropylene, and polyamide. PLA has an excellent wickability, fast fluid spreading, and rapid drying.PLA fibre has been utilised in the diaper and feminine hygiene markets due to its superior wicking properties. Main advantage of biodegradable and bio-adsorbable fibres is that no further surgery is required as they slowly degrade and absorbed by tissues in the body without any side effects. It is also used in orthopaedic applications such as bone support splints. Casts and splints are orthopedic devices that are used to protect and support fractured or injured bones and joints. They help to immobilize the injured limb to keep the bone in place until it fully heals. Casts are often made from fiberglass or plaster. PLA waste can be processed using composting, chemical recycling and anaerobic digestion [38-40].

Polycaprolactone: PCL is semi-crystalline polyester which is biodegradable and biocompatible. It is used in tissue engineering; 3-D wound dressing, wound and burn dressing, etc. Many scientists successfully developed 3-D printed wound dressing in corporation with Ag, Cu, Zn, into PCL filaments by making use of hot melt extrusion.[41]

***Chitosan/chitin wound dressing*:** Chitin is a polysaccharide found in nature. Commercial source of chitin is from shrimp shells but it also occurs in many fungi. Chitosan is deacetylated form of chitin. Chitosan fibre is much easier to make due to its better solubility. It has properties such as hemostatic, bacteriostatic, anti-tumour, fungistatic, biocompatible, etc. N-carboxybutyl chitosan dressing is used for plastic surgery donor sites [42]. These dressings are excellent materials for wound care management as these exhibits properties such as high gel content, tensile strength, elongation at break, etc. Chitosan coated gauze was found to be effective against microorganisms. Silver sulphadizine incorporated chitosan membrane with sustained anti-microbial capability has been developed by dry/wet separation method. CS modified bacterial cellulose provides optimal moisture conditions for rapid wound healing, stimulates wound healing without irritation. Also it gives properties such as bioactivity, biocompatibility of two biopolymers. Therefore it is an excellent dressing material [43].

***Nanofibres containing silver nanoparticles for wound dressing*:** Nanocoated materials like smart clothing are the recent innovations. Nanoparticles are now considered a viable alternative to antibiotics and seem to have a high potential to solve the problem of the emergence of bacterial multidrug resistance. In particular, silver nanoparticles (AgNPs) have attracted much attention in the scientific field. Silver has always been used against various diseases; in the past it found use as an antiseptic and antimicrobial against Gram-positive and Gram-negative bacteria. Silver ions interact with a number of electron donor functional groups such as thiols, phosphates, hydroxyls, imidazoles and indoles. The AgNPs also damage membranes and induce the release of reactive oxygen species (ROS), forming free radicals with a powerful bactericidal action. Silver ions or small AgNPs can easily enter the microbial body causing the damage of its intracellular structures [44,45]. Nanofibres have various unique properties such as high surface area to volume ratio, film thinness, nano scale fibre diameter, porosity and also it is light weight. Therefore they are used for wound dressing. PVA nanofibres containing silver nanoparticles were prepared by electrospinning PVA/silver nitrate (AgNO3) aqueous solutions then short heat treatment is done. It is suitable for wound dressing because of their anti-microbial activity. Silver has been known to have anti-microbial properties and hence antibacterial disinfection and finishing techniques are developed for many types of textiles using treatment with nanosized silver [46-48].

Collagen based wound dressing: Collagen is the most abundant protein in our body. It is major component of connective tissues that make makeup several body parts including tendons, ligaments, skin and muscles. It has excellent biocompatibility therefore it is used as major component of artificial tissues and wound dressing. It is a natural material with low immunogenicity. Collagen based wound dressing enhances the deposition of oriented organised collagen fibre characteristics of the remodelling phase of wound healing. Mechanical properties of collagen fibres are improved by cross linking [49].

CONCLUSION

Literature on wound and dressing is enormous and large number of textile materials has been used and developed for various applications in wound dressing and management. This review increases the understanding of the importance and features of these fibres. Many plant or plant derived compounds were discussed with their excellent properties have benefits in wound healing. Developments in order to use traditional medicine in wound management are being researched. Smart wound dressing enhances the suitability for the treatments of various wound types and their performances in wound healing process.

Biopolymers along with the textile materials provide all the specifications required for smart wound dressing. Various developments along with their properties, advantages, disadvantages have been discussed. Advanced wound dressing gives excellent wound healing compared to basic conventional wound dressing.

REFERENCES

[1] MihaelaGeorgescu, Oana Marinas, Marcela Popa, Teodora Stan, Veronica Lazar, SerbanViforBertesteanu and Mariana Carmen Chifiriuc (December 7th 2016), Natural Compounds for Wound Healing, Cesar Joao Vicente da Fonseca (Eds), Worldwide Wound Healing,Innovation in Natural and Conventional Methods, intechopen.

[2] Gupta Bhuvanesh, Agrawal Roopali, Alam M.S, 2010. Textile-based smart wound dressing. Department of textile technology and department of chemistry, 35, pp. 174-187.

[3] Majno, Guido 1975. The healing hand: Man and wound in the ancient world, Commonwealth Fund Publications, Masachussets , Harvard university press, p. 571-600.

[4] Hosseinkhani A, Falahatzadeh M, Raoofi E, Zarshenas MM, 2016. An evidence-based review on wound healing herbal remedies from reports of traditional Persian medicine . J Evid Based Complementary Altern Med, 22(2), 334-343.

[5] Uzun M.A, 2018. A review of wound management materials, J textile eng fashion technology, Department of textile engineering, 4(1), 53-59.

[6] A., Nangia, C.T., Hung, 1990. Preclinical evaluation of skin substitutes. Department of pharmacy, 16(5), 358-367.

[7] WINTER G. D. (1962). Formation of the scab and the rate of epithelization of superficial wounds in the skin of the young domestic pig. Nature, 193, 293–294.

[8] Kennedy, J. F., Paterson, M., Knill, C. J. And Lloyd, L. L., The diversity of properties of polysaccharides as wound management aids, and characterisation of their structures

[9] Lloyd, L. L., Kennedy, J. F., Methacanon, P., Paterson, M. And Knill, C. J., Carbohydrate polymers as wound management aids, Carbohydr. Polym., Special Issue—Gluportwo, 1998, 37, 315-322.

[10] Kokabi, M., Sirousazar, M. And Hassan, Z.M. (2007) PVA-Clay Nanocomposite Hydrogels for Wound Dressing. European Polymer Journal, 43, 773-781.

[11] Watson NFS, Hodgkin W. Wound Dressings. Surgery 2005. 23(2), 52-5.

[12] Bolton, L L et al. (2000). "Moisture and healing: beyond the jargon." Ostomy/wound management vol. 46, 51S-62S; quiz 63S-64S.

[13] Clark R. A. (1985). Cutaneous tissue repair: basic biologic considerations. I. Journal of the American Academy of Dermatology, 13, 701–725.

[14] Martin P. (1997). Wound healing-aiming for perfect skin regeneration. Science (New York, N.Y.), 276(5309), 75–81.

[15] Singer, A. J., & Clark, R. A. (1999). Cutaneous wound healing. The New England journal of medicine, 341(10), 738–746.

[16] Petrulyte S. (2008). Advanced textile materials and biopolymers in wound management. Danish medical bulletin, 55(1), 72–77.

[17] Thangapazham RL., Sharad S., Maheshwari RK., 2016. Phytochemicals in Wound Healing. Adv Wound Care (New Rochelle), 5(5), 230–241.

[18] S. Choi and M. H. Chung, 2003. "A review on the relationship between aloe vera components and their biologic effects," Seminars in Integrative Medicine, 1, pp. 53–62.

[19] Radha, M. H., &Laxmipriya, N. P. (2014). Evaluation of biological properties and clinical effectiveness of Aloe vera: A systematic review. Journal of traditional and complementary medicine, 5(1), 21–26.

[20] Hashemi, S. A., Madani, S. A., &Abediankenari, S. (2015). The Review on Properties of Aloe Vera in Healing of Cutaneous Wounds. BioMed research international, 2015, 714216.

[21] Tummalapalli M., Berthet M., Verrier B., Deopura BL., Alam MS., Gupta B., 2016. Composite wound dressings of pectin and gelatin with aloe vera and curcumin as bioactive agents. Int. J. Biol. Macromol, 82, 104–113.

[22] Mahmood K., Zia KM., Zuber M., Salman M., Anjum MN., 2015. Recent developments in curcumin and curcumin based polymeric materials for biomedical applications: A review. Int. J. Biol. Macromol, 81, 877-890.

[23] Naksuriya, O., Okonogi, S., Schiffelers, R. M., &Hennink, W. E. (2014). Curcuminnanoformulations: a review of pharmaceutical properties and preclinical studies and clinical data related to cancer treatment. Biomaterials, 35(10), 3365–3383.

[24] Bardaa, S., Ben Halima, N., Aloui, F., Ben Mansour, R., Jabeur, H., Bouaziz, M., &Sahnoun, Z. (2016). Oil from pumpkin (Cucurbita pepo L.) seeds: evaluation of its functional properties on wound healing in rats. Lipids in health and disease, 15, 73.

[25] Fahimi, S., Abdollahi, M., Mortazavi, S. A., Hajimehdipoor, H., Abdolghaffari, A. H., &Rezvanfar, M. A. (2015). Wound Healing Activity of a Traditionally Used Poly Herbal Product in a Burn Wound Model in Rats. Iranian Red Crescent medical journal, 17(9).

[26] Dinda M., Dasgupta U., Singh N., Bhattacharyya D., Karmakar P., 2015. PI3K-mediated proliferation of fibroblasts by Calendula officinalis tincture: implication in wound healing. Phytother. Res, 29, 607–616.

[27] Gore, M. A., &Akolekar, D. (2003). Evaluation of banana leaf dressing for partial thickness burn wounds. Burns : journal of the International Society for Burn Injuries, 29(5), 487–492.

[28] Sivamani, R. K., Ma, B. R., Wehrli, L. N., &Maverakis, E. (2012). Phytochemicals and Naturally Derived Substances for Wound Healing. Advances in wound care, 1(5), 213–217.

[29] De Armas, E., Sarracent, Y., Marrero, E., Fernández, O., & Branford-White, C. (2005). Efficacy of Rhizophora mangle aqueous bark extract (RMABE) in the treatment of aphthous ulcers: a pilot study. Current medical research and opinion, 21(11), 1711–1715.

[30] Silva-Carvalho, R., Baltazar, F., & Almeida-Aguiar, C. (2015). Propolis: A Complex Natural Product with a Plethora of Biological Activities That Can Be Explored for Drug Development. Evidence-based complementary and alternative medicine.

[31] Gregory, S. R., Piccolo, N., Piccolo, M. T., Piccolo, M. S., &Heggers, J. P. (2002). Comparison of propolis skin cream to silver sulfadiazine: a naturopathic alternative to antibiotics in treatment of minor burns. Journal of alternative and complementary medicine (New York, N.Y.), 8(1), 77–83.

[32] Fitzmaurice, S. D., Sivamani, R. K., &Isseroff, R. R. (2011). Antioxidant therapies for wound healing: a clinical guide to currently commercially available products. Skin pharmacology and physiology, 24(3), 113–126.

[33] Jull, A. B., Rodgers, A., & Walker, N. (2008). Honey as a topical treatment for wounds. The Cochrane database of systematic reviews, (4), CD005083.

[34] TarigAbdelrahman, Heather Newton, 2011. Wound dressings: principles and practice,Surgery (Oxford), 29 (10), 491-495,

[35] Park K R., Nho Y C., 2003, Synthesis of PVA/PVP hydrogels having two-layer by radiation and their physical properties, Radiation Physics and Chemistry, 67, 361-365.

[36] Chapman DJ. Algin and alginates, 1980. Seaweeds and their uses, third ed. Chapman and Hall, New York, pp. 194-226.

[37] Anand SC, Kennedy JF, Miraftab M, et al. 2006. Medical textiles and biomaterials for healthcare. Cambridge, Woodhead publishing, p. 499–508.

[38] Lunt J., 2000. Polylactic Acid Polymers for Fibers and Nonwovens. International FiberJ,Chemistry

[39] Rajeev Mehta, Vineet Kumar, HaripadaBhunia& S. N. Upadhyay (2005) Synthesis of Poly(Lactic Acid): A Review, Journal of Macromolecular Science, Part C, 45:4, 325-349.

[40] Sagala HF, KuberaSampath Kumar S, Subramanian S, et al., 2009. PLA (polylactic acid) nanofibers for medical application. Arena Tekstil 24(2), 94–101.

[41] Muwaffak, Z., Goyanes, A., Clark, V., Basit, A. W., Hilton, S. T., &Gaisford, S. (2017). Patient-specific 3D scanned and 3D printed antimicrobial polycaprolactone wound dressings. International journal of pharmaceutics, 527(1-2), 161–170.

[42] Muzzarelli, R., Tarsi, R., Filippini, O., Giovanetti, E., Biagini, G., &Varaldo, P. E. (1990). Antimicrobial properties of N-carboxybutyl chitosan. Antimicrobial agents and chemotherapy, 34(10), 2019–2023.

[43] Shuai Zhang, Jin Luo, 2011. Preparation and Properties of Bacterial Cellulose/Alginate Blend Bio-Fibers. Journal of Engineered Fibers and Fabrics, 6(3), 69-72.

[44] Sathiyapriya, R, Hariharan, V, Prabakaran, K, Durairaj, M, Aroulmoji V, 2019. Nanotechnology in Materials and Medical Sciences, Int. J. Adv. Sci. Eng. 5(3) 1077-1084.

[45] Franci, G., Falanga, A., Galdiero, S., Palomba, L., Rai, M., Morelli, G., &Galdiero, M. (2015). Silver nanoparticles as potential antibacterial agents. Molecules (Basel, Switzerland), 20(5), 8856–8874.

[46] Graham K, Schreuder G H &Gogins M., 2003. Incorporation of electrospun nanofibers into functional structures, paper presented at the International Nonwoven Technical Conference, Baltimore, USA, 15-18.

[47] Hong K H, Park J L, Sul I H, Youk J H & Kang T J., 2006. J PolymSci [PartB], PolymPhys, 44, 2468.

[48] Lee, H.J., Yeo, S.Y. &Jeong, S.H., 2003. Antibacterial effect of nanosized silver colloidal solution on textile fabrics. Journal of Materials Science 38, 2199–2204.

[49] Yuan Le, S. Anand, A. Horrocks, 1997. Recent developments in fibres and materials for wound management, Indian journal of fibre and textile research, 22, 337-347.

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